

IN THE CLAIMS:

Claim 1 (currently amended): A noise checking method used upon circuit designing for checking noise which has an influence on a signal waveform which propagates in a noticed wiring line on a design object circuit, comprising the steps of:

producing a simulation model of a circuit portion relating to the noticed wiring line;

performing a simulation using the simulation model to calculate a signal waveform which propagates in the noticed wiring line and calculate a noise waveform superposed on the signal waveform in the noticed wiring line for a plurality of kinds of noise;

synthesizing with generation timings of the noise waveforms taken into consideration the signal waveform and the noise waveforms calculated for each of the plurality of kinds of noise ~~with generation timings of the noise waveforms taken into consideration~~ to obtain a noise composite waveform which is the signal waveform on which the noise is superposed; and

performing noise checking based on the noise composite waveform;

wherein when the noise checking is performed, a maximum delay time and a minimum delay time of the noticed wiring line are extracted from the noise composite waveform, and overdelay/racing checking for the noticed wiring line is performed using the maximum delay time and the minimum delay time.

Claim 2 (original): The noise checking method as set forth in claim 1, characterized in that, where an adjacent wiring line to the noticed wiring line is turned back in such a manner as to have a plurality of proximate portions which can electrically interfere with the noticed wiring line,

simulation models are produced with regard to the individual proximate portions of the adjacent wiring line and the noticed wiring line and the noise waveforms are calculated using the simulation models, and then the noise waveforms calculated with regard to all of the proximate portions and the signal waveform are synthesized with generation timings of the noise waveforms taken into consideration.

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Claim 3 (Canceled): The noise checking method as set forth in claim 1, characterized in that, when the noise checking is performed, a maximum delay time and a minimum delay time of the noticed wiring line are extracted from the noise composite waveform, and overdelay/racing checking for the noticed wiring line is performed using the maximum delay time and the minimum delay time.

Claim 4 (original): The noise checking method as set forth in claim 1, characterized in that, where the signal waveform which propagates in the noticed wiring line is a clock waveform, when the noise checking is performed, a pulse period of the noise composite waveform is calculated from crossing points of the noise composite waveform and a high level discrimination threshold value/low level discrimination threshold value for the signal waveform, and pulse period checking of the clock waveform in the noticed wiring line is performed based on the pulse period.

Claim 5 (original): The noise checking method as set forth in claim 1, characterized in that, where the signal waveform which propagates in the noticed wiring line is a clock waveform, when

the noise checking is performed, a rising width and a falling width of the noise composite waveform are calculated from crossing points of the noise composite waveform and a high level discrimination-threshold value/low level discrimination threshold value for the signal waveform, and pulse width checking of the clock waveform in the noticed wiring line is performed based on the rising width and the falling width.

Claim 6 (original): The noise checking method as set forth in claim 1, characterized in that, where the signal waveform which propagates in the noticed wiring line is a clock waveform, when the noise checking is performed, a time required for the noise composite waveform to rise and another time required for the noise composite waveform to fall are calculated from crossing points of the noise composite waveform and a high level discrimination threshold value/low level discrimination threshold value for the signal waveform, and checking of the rising time/falling time of the clock waveform in the noticed wiring line is performed based on the times.

Claim 7 (original): The noise checking method as set forth in claim 1, characterized in that, when the simulation is performed, the simulation model is divided into a plurality of files, and simulations with regard to the plurality of files are executed individually by a plurality of processing sections of a parallel processor which operate parallelly, whereafter simulation result files by said plurality of processing sections are combined.

Claim 8 (original): The noise checking method as set forth in claim 1, characterized in that,

when the simulation is performed, the simulation model is divided into a plurality of files, and simulations with regard to the plurality of files are executed individually by a plurality of processing sections—interconnected over a network, whereafter simulation result files by said plurality of processing sections are combined.

Claim 9 (original): The noise checking method as set forth in claim 1, characterized in that it further comprises the steps of:

performing a noise analysis with regard to the noise composite waveform;

displaying, if a questionable wiring line which has a bad influence on the noticed wiring line is found by the noise analysis, a wiring line pattern including the noticed wiring line and the questionable wiring line on a display section;

calculating, if the questionable wiring line displayed on said display section is moved on said display section by means of a pointing device, an actual movement amount of the questionable wiring line corresponding to an amount of the movement by said pointing device;

performing, in the state wherein the questionable wiring line is moved by the actual movement amount, the production of the simulation model, the simulation, the synthesis of the noise composite waveform and the noise checking again; and

displaying the noise composite waveform after the movement of the questionable wiring line on said display section.


Claim 10 (original): The noise checking method as set forth in claim 1, characterized in that it further comprises the steps of:

performing a noise analysis with regard to the noise composite waveform;

displaying, if a noise waveform which has a bad influence on the noticed wiring line is

found by the noise analysis, the noise waveform on a display section; and

calculating, if the noise waveform displayed on said display section is moved on said display section by means of a pointing device, a timing changing amount of the noise waveform corresponding to an amount of the movement by said pointing device and dynamically changing a generation timing of the noise waveform by the timing changing amount.

 Claim 11 (original): The noise checking method as set forth in claim 10, characterized in that the synthesis of the noise composite waveform and the noise checking are performed again using the noise waveform whose generation timing has been dynamically changed, and the noise composite waveform after the timing changing of the noise waveform is displayed on said display section.

Claim 12 (original): The noise checking method as set forth in claim 1, characterized in that it further comprises the steps of:

calculating, where ringing is superposed on the noise composite waveform, a damping resistance value with which the ringing can be eliminated if the damping resistor is added to the noticed wiring line;

displaying candidate part data corresponding to the damping resistance value on said display section;

performing, in a state wherein a part selected from among the candidate part data is added to the noticed wiring line, the production of the simulation model, the simulation, the synthesis of the noise composite waveform and the noise checking again; and

displaying the noise composite waveform after the addition of the part on said display section.

Claim 13 (original): The noise checking method as set forth in claim 1, characterized in that,

in order to obtain the noise composite waveform,

time axis direction distributions of a maximum value and a minimum value of the signal waveform with a delay variation taken into consideration are calculated and time axis direction distributions of a maximum value and a minimum value of a noise waveform with a noise generation timing variation taken into consideration are calculated for each kind of noise, and

time axis direction distributions of the maximum value and the minimum value obtained by synthesizing the time axis direction distributions of the maximum value and the minimum value of the signal waveform and the time axis direction distributions of the maximum value and the minimum value of the noise waveforms are used as the noise composite waveform.

Claim 14 (original): The noise checking method as set forth in claim 13, characterized in that, when the noise checking is performed, it is discriminated whether or not both of the time axis direction distributions of the maximum value and the minimum value of the noise composite

waveform satisfy logical expected values for a check object pin.

Claim 15 (original): The noise checking method as set forth in claim 13, characterized in that,

when the simulation is performed, a single signal waveform is calculated under a predetermined condition and a single noise waveform for each kind of noise is calculated under the predetermined condition, and,

when the noise composite waveform is obtained, the single signal waveform calculated is shifted within a range of the delay variation to calculate time axis direction distributions of the maximum value and the minimum value of the signal waveform and the single noise waveform calculated is shifted within a range of the noise generation timing variation to calculate, for each kind of noise, time axis direction distributions of the maximum value and the minimum value of the noise waveform.

Claim 16 (original): The noise checking method as set forth in claim 13, characterized in that, where the noise waveform exists across a plurality of clock cycles, a maximum value compressed noise waveform and a minimum value compressed noise waveform, in which maximum values and minimum values of the noise waveform are compressed into one clock cycle respectively, are produced by extracting the maximum values and the minimum values of the noise waveform in the same phase of each clock cycle from the clock cycles respectively, and the compressed noise waveforms are used as the time axis direction distributions of the maximum

value and the minimum value of the noise waveform, respectively.


Claim 17 (original): The noise checking method as set forth in claim 13, characterized in that, when an overdelay check of the signal waveform is performed by the noise checking, upon rising of the signal waveform, a waveform obtained by synthesizing the time axis distribution of the minimum value of the noise waveform with the signal waveform is used as the noise composite waveform, but upon falling of the signal waveform, another waveform obtained by synthesizing the time axis distribution of the maximum value of the noise waveform with the signal waveform is used as the noise composite waveform.

Claim 18 (original): The noise checking method as set forth in claim 13, characterized in that, when a racing check of the signal waveform is performed by the noise checking, upon rising of the signal waveform, a waveform obtained by synthesizing the time axis distribution of the maximum value of the noise waveform with the signal waveform is used as the noise composite waveform, but upon falling of the signal waveform, another waveform obtained by synthesizing the time axis distribution of the minimum value of the noise waveform with the signal waveform is used as the noise composite waveform.

Claim 19 (currently amended): A noise checking apparatus used upon circuit designing for checking noise which has an influence on a signal waveform which propagates in a noticed wiring line on a design object circuit comprising:

a model production section (3) for producing a simulation model of a circuit portion relating to the noticed wiring line;

a simulation section (4) for performing a simulation using the simulation model produced by said model production section (3) to calculate a signal waveform which propagates in the noticed wiring line and calculate a noise waveform superposed on the signal waveform in the noticed wiring line for a plurality of kinds of noise;

 a noise waveform synthesis section (5) for synthesizing with generation timings of the noise waveforms taken into consideration the signal waveform and the noise waveforms calculated by said simulation section (4) ~~with generation timings of the noise waveforms taken into consideration~~ to obtain a noise composite waveform which is the signal waveform on which the noise is superposed; and

a noise checking section (6) for performing noise checking based on the noise composite waveform obtained by said noise waveform synthesis section (5);

wherein said noise checking section (6) extracts a maximum delay time and a minimum delay time of the noticed wiring line from the noise composite waveform and performs overdelay/racing checking for the noticed wiring line using the maximum delay time and the minimum delay time.

Claim 20 (original): The noise checking apparatus as set forth in claim 19, characterized in that, where an adjacent wiring line to the noticed wiring line is turned back in such a manner as to have a plurality of proximate portions which can electrically interfere with the noticed wiring

line, said model production section (3) produces simulation models with regard to the individual proximate portions of the adjacent wiring line and the noticed wiring line and said simulation section (4) calculates the noise waveforms using the simulation models, and then said noise waveform synthesis section (5) synthesizes the noise waveforms calculated with regard to all of the proximate portions and the signal waveform with generation timings of the noise waveforms taken into consideration.

Claim 21 (Canceled): The noise checking apparatus as set forth in claim 19, characterized in that said noise checking section (6) extracts a maximum delay time and a minimum delay time of the noticed wiring line from the noise composite waveform and performs overdelay/racing checking for the noticed wiring line using the maximum delay time and the minimum delay time.

Claim 22 (original): The noise checking apparatus as set forth in claim 19, characterized in that, where the signal waveform which propagates in the noticed wiring line is a clock waveform, said noise checking section (6) calculates a pulse period of the noise composite waveform from crossing points of the noise composite waveform and a high level discrimination threshold value/low level discrimination threshold value for the signal waveform and performs pulse period checking of the clock waveform in the noticed wiring line based on the pulse period.

Claim 23 (original): The noise checking apparatus as set forth in claim 19, characterized in that, where the signal waveform which propagates in the noticed wiring line is a clock waveform,

said noise checking section (6) calculates a rising width and a falling width of the noise composite waveform from crossing points of the noise composite waveform and a high level discrimination threshold value/low level discrimination threshold value for the signal waveform and performs pulse width checking of the clock waveform in the noticed wiring line based on the rising width and the falling width.

Claim 24 (original): The noise checking apparatus as set forth in claim 19, characterized in that, where the signal waveform which propagates in the noticed wiring line is a clock waveform, said noise checking section (6) calculates a time required for the noise composite waveform to rise and another time required for the noise composite waveform to fall from crossing points of the noise composite waveform and a high level discrimination threshold value/low level discrimination threshold value for the signal waveform and performs checking of the rising time/falling time of the clock waveform in the noticed wiring line based on the times.

Claim 25 (original): The noise checking apparatus as set forth in claim 19, characterized in that said simulation section (4) includes:

- a file dividing section for dividing the simulation model into a plurality of files;
- a parallel processor having a plurality of processing sections for executing simulations with regard to the plurality of files obtained by the division of said file dividing section parallelly;
- and
- a file combining section for combining simulation result files by said plurality of

processing sections.

Claim 26 (original): The noise checking apparatus as set forth in claim 19, characterized in that said simulation section (4) includes:

a file dividing section for dividing the simulation model into a plurality of files;

a network interconnecting a plurality of processing sections for executing simulations with regard to the plurality of files parallelly; and

a file combining section for combining simulation result files by said plurality of processing sections.

Claim 27 (original): The noise checking apparatus as set forth in claim 19, characterized in that it further comprises:

a noise composite waveform analysis section for performing a noise analysis with regard to the noise composite waveform;

a display section for displaying, if a questionable wiring line which has a bad influence on the noticed wiring line is found by said noise composite waveform analysis section, a wiring line pattern including the noticed wiring line and the questionable wiring line;

a pointing device for moving the questionable wiring line displayed on said display section on said display section; and

a movement amount calculation section for calculating an actual movement amount of the questionable wiring line corresponding to an amount of the movement by said pointing device; and

that,

in the state wherein the questionable wiring line is moved by the actual movement amount, said model production section (3), said simulation section (4), said noise waveform synthesis section (5) and said noise checking section (6) are operated again and the noise composite waveform after the movement of the questionable wiring line is displayed on said display section.

Claim 28 (original): The noise checking apparatus as set forth in claim 19, characterized in that it further comprises:

a noise composite waveform analysis section for performing a noise analysis with regard to the noise composite waveform;

a display section for displaying, if a noise waveform which has a bad influence on the noticed wiring line is found by said noise composite waveform analysis section, the noise waveform; and

a timing changing amount calculation section for calculating a timing changing amount of the noise waveform corresponding to an amount of the movement by said pointing device and dynamically changing a generation timing of the noise waveform by the timing changing amount.

Claim 29 (original): The noise checking apparatus as set forth in claim 28, characterized in that said noise waveform synthesis section (5) and said noise checking section (6) are operated again in a state wherein the generation timing of the noise waveform is changed, and the noise composite waveform after the timing changing of the noise waveform is displayed on said display

section.

Claim 30 (original): The noise checking apparatus as set forth in claim 19, characterized in that it further comprises:

a damping resistance value calculation section for calculating, where ringing is superposed on the noise composite waveform, a damping resistance value with which the ringing can be eliminated if the damping resistor is added to the noticed wiring line;

a part searching section for searching for candidate part data corresponding to the damping resistance value calculated by said damping resistance value calculation section;

a displaying section for displaying the candidate part data searched out by said part searching section; and

a selective inputting section for selecting a part from among the candidate part data displayed on said display section; and that,

in a state wherein the part selected from among the candidate part data is added to the noticed wiring line, said model production section (3), said simulation section (4), said noise waveform synthesis section (5) and said noise checking section (6) are operated again, and the noise composite waveform after the addition of the part is displayed on said display section.

Claim 31 (original): The noise checking apparatus as set forth in claim 19, characterized in that said noise waveform synthesis section (5)

calculates time axis direction distributions of a maximum value and a minimum value of

the signal waveform with a delay variation taken into consideration and calculates time axis direction distributions of a maximum value and a minimum value of a noise waveform with a noise generation timing variation taken into consideration for each kind of noise, and

synthesizes the time axis direction distributions of the maximum value and the minimum value of the signal waveform and the time axis direction distributions of the maximum value and the minimum value of the noise waveforms to obtain time axis direction distributions of the maximum value and the minimum value as the noise composite waveform.

Claim 32 (original): The noise checking apparatus as set forth in claim 31, characterized in that said noise checking section (6) discriminates whether or not both of the time axis direction distributions of the maximum value and the minimum value of the noise composite waveform satisfy logical expected values for a check object pin to perform the noise checking.

Claim 33 (original): The noise checking apparatus as set forth in claim 31, characterized in that

said simulation section (4) calculates a single signal waveform under a predetermined condition and calculates a single noise waveform for each kind of noise under the predetermined condition, and

said noise waveform synthesis section (5) shifts the calculated single signal waveform within a range of the delay variation to calculate time axis direction distributions of the maximum value and the minimum value of the signal waveform and shifts the calculated single noise

waveform for each kind of noise within a range of the noise generation timing variation to calculate, for each kind of noise, time axis direction distributions of the maximum value and the minimum value of the noise waveform.

Claim 34 (original): The noise checking apparatus as set forth in claim 31, characterized in that, where the noise waveform exists across a plurality of clock cycles, said noise waveform synthesis section (5) extracts maximum values and minimum values of the noise waveform in the same phase of each clock cycle from the clock cycles respectively to produce a maximum value compressed noise waveform and a minimum value compressed noise waveform wherein the maximum values and the minimum values of the noise waveform are compressed into one clock cycle respectively, and uses the compressed noise waveforms as the time axis direction distributions of the maximum value and the minimum value of the noise waveform, respectively.

Claim 35 (original): The noise checking apparatus as set forth in claim 31, characterized in that, when said noise checking section (6) performs an overdelay check of the signal waveform, said noise waveform synthesis section (5) synthesizes, upon rising of the signal waveform, the time axis distribution of the minimum value of the noise waveform with the signal waveform to obtain the noise composite waveform, but synthesizes, upon falling of the signal waveform, the time axis distribution of the maximum value of the noise waveform with the signal waveform to obtain the noise composite waveform.

Claim 36 (original): The noise checking apparatus as set forth in claim 31, characterized in that, when said noise checking section (6) performs a racing check of the signal waveform, said noise waveform synthesis section (5) synthesizes, upon rising of the signal waveform, the time axis distribution of the maximum value of the noise waveform with the signal waveform to obtain the noise composite waveform, but synthesizes, upon falling of the signal waveform, the time axis distribution of the minimum value of the noise waveform with the signal waveform to obtain the noise composite waveform.